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Case report

Life threatening chop injuries to the head: Optimising injury interpretation using three dimensional computerised tomography (3DCT) reconstruction of pre-treatment imaging

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ABSTRACT

Computerised tomography (CT) is being increasingly advocated to support post mortem investigation of death but the value of using CT data already captured during emergency imaging, prior to treatment of life threatening injuries, remains under recognised and inadequately explored. We demonstrate the value of three dimensional computerised tomography (3D CT) reconstructions of such data, in interpreting the injuries sustained by a male who survived after being subjected to an assault with an axe and whose surface injuries had been debrided and sutured, before any photography was undertaken. The 3D CT images captured most of the scalp, face and skull vault trauma prior to the surgical intervention. Taken with other evidence, this indicated that the victim had received at least four separate blows to the face and head with a sharp chopping weapon; evidence which proved to be centrally important in the subsequent criminal court proceedings. This case also illustrated the effectiveness of joint interpretation of 3D CT reconstructed images in medico-legal casework, by experienced consultants in forensic pathology and radiology and the potential value of reviewing emergency pre-treatment CT imaging in any serious head injury allegedly sustained in an assault. This is likely to be particularly valuable when sharp or blunt weapon damage to bone is suspected.

1. Introduction

The value of computerised tomography (CT) imaging in forensic pathology and autopsy practice has become increasingly well recognised since its early reported use.[1,2] A number of international centres including the Victoria Institute of Forensic Medicine,[3] the Institutes of Forensic Medicine in Copenhagen[4] and Berne (Switzerland)[5] routinely use the modality, either as the primary tool for establishing the cause of death or, more commonly, as an adjunct to invasive post mortem investigation.[6] The use of post mortem CT is perhaps most widely accepted in forensic practice in relation to ballistic injury and bone fracture, where 3D reconstruction is particularly helpful especially for court presentation purposes. Whilst it has been advocated for use in all forensic post mortem investigations,[7] the modality is currently only regularly used in a few forensic centres within the United Kingdom. Debate continues as to the feasibility and value of introducing CT more widely into general death investigation in the United Kingdom. Perceived difficulties include the patchy availability of scanners for non-clinical use,[8] funding restraints, lack of experience in interpreting post mortem images and current limitations in the diagnosis of some common pathological processes such as pulmonary thromboembolism and significant coronary artery disease; problems hampered further by any putrefactive changes in the body.[3] The development of various approaches to post mortem angiography is clearly addressing some of these limitations in interpretation. In contrast, the potential value of using already captured CT data taken for clinical treatment purposes from seriously injured individuals is only recently becoming recognised.[9–11] We present a case in which three dimensional (3D) reconstruction of the pre-treatment imaging, proved central to the interpretation of chop wounds sustained by an individual allegedly attacked with an axe.

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2. Case report

An adult male was allegedly assaulted with a hand axe during an altercation at a house. The victim was conscious and bleeding heavily from open scalp wounds of an undocumented number and distribution. He was taken to the local hospital where an emergency CT scan of the head was performed. This showed a frontal vault fracture with a number of intruding small intracranial bone fragments, a small subdural haematoma and fractures of the nose and left zygoma complex. The victim was transferred to the regional neurosurgical centre where the wounds were explored, debrided and closed with sutures. He made a full recovery without the need for invasive neurosurgery. As part of the police investigation, expert opinion was sought in relation to the nature of the injuries sustained and, in particular, the number of likely blows received to the head with the alleged weapon. The medical records, key items of clothing (including a cap), the CT data and a series of photographs were made available for review. The photographs had been taken post operatively (approximately 3–4 days following the incident) and were sub-optimal, having been captured on a mobile phone camera.

2.1. Interpretation of material

The post treatment photographs (although slightly out of focus), clearly show a series of sutured healing linear and curved wounds, to the left side of the scalp and upper face (Figs. 1 and 2). It was unclear from the clinical records whether the surface wounds represented inflicted incised wounds and/or lacerations, or wounds largely modified by surgical extension. The cap (Fig. 3) worn by the victim at the time of the incident, was blood stained and showed a single cleanly cut defect over the left posterior parietal area. The instructed forensic pathologist asked for 3D reconstruction of the CT data to be performed in order to see whether focal chop damage, correlating with the cut damage to the victim's cap and the sutured wounds in the photographs, could be identified on the skull vault. This was undertaken with soft tissue and bone rendering, using a DICOM viewer (Osirix) on an Apple Mac computer. The reconstructed images were jointly interpreted by consultants in forensic pathology and musculo-skeletal radiology. There were several key observations:

Fig. 1. Post treatment photograph showing sutured healing linear and curved wounds to central face and anterior scalp.

Fig. 2. Post treatment photograph demonstrating sutured healing linear and curved wounds to face, frontal and left side of scalp.

(1) A defined chop fracture with lifted external vault component positioned over the left frontal bone (Fig. 4).
(2) A long linear fracture (Fig. 4) extended downwards from the chop fracture across the frontal bone towards the right orbit. Fig. 5, which includes some residual soft tissue rendering on the vault, demonstrates a parallel line within the soft tissue, indicating an incision through the overlying scalp. This defines the linear bone defect as a further chop injury site rather than a radiating fracture line.
(3) A defined chop fracture with lifted external vault component, positioned on the left side of the top of the skull vault (Figs. 4

Fig. 3. The cap worn at the time of the incident with a single cleanly cut defect to left posterior parietal area (arrowed).

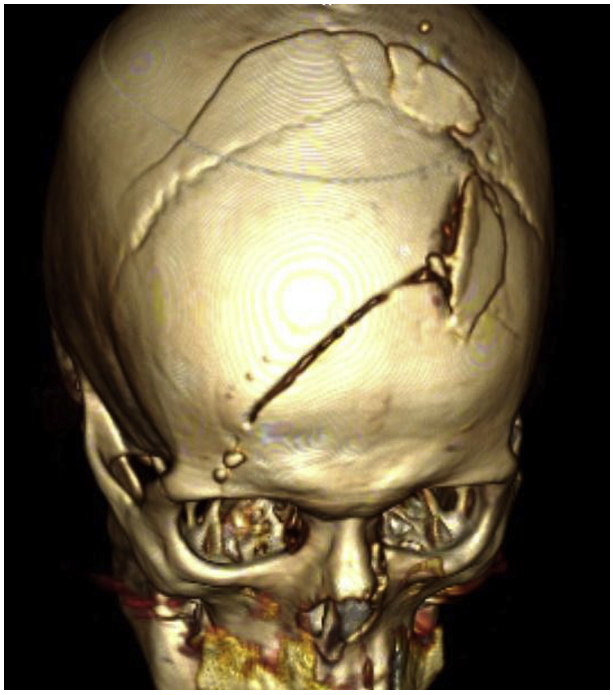

Fig. 4. 3D CT reconstruction of facial bones and anterior skull vault showing chop impact damage sites.

and 6); a curved radiating fracture extends over the vault to the right parietal bone.

(4) A short linear bone groove on the surface of the vault over the left side of the back of the head (Fig. 6), correlating in position and orientation with the cut defect on the cap.

(5) Irregular fracturing across the nose (Fig. 4) is seen to be associated with an incised-looking wound in the skin visible on the surface rendering (Fig. 7), providing strong support for an additional chop injury site.

The impact fracturing correlates well with the position of the sutured surface wounds in the photographs and the findings were considered to indicate the landing of at least four, and very probably five, separate forceful blows to the head with an axe-like weapon.

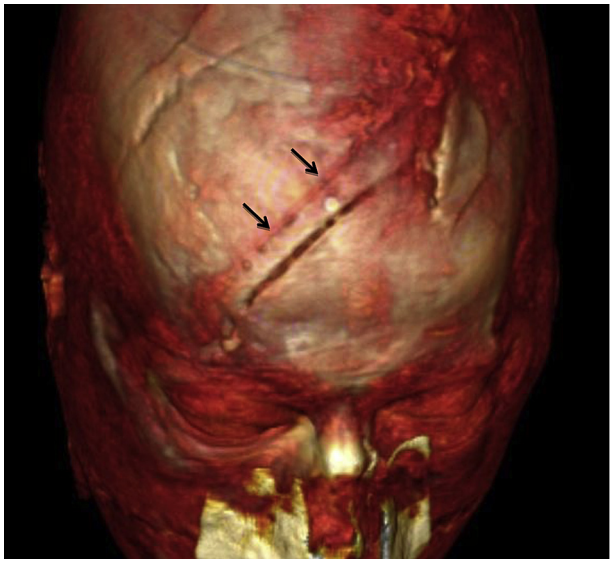

Fig. 5. 3D CT reconstruction with residual soft tissue rendering showing linear soft tissue defect (arrowed) orientated parallel to linear frontal skull impact defect.

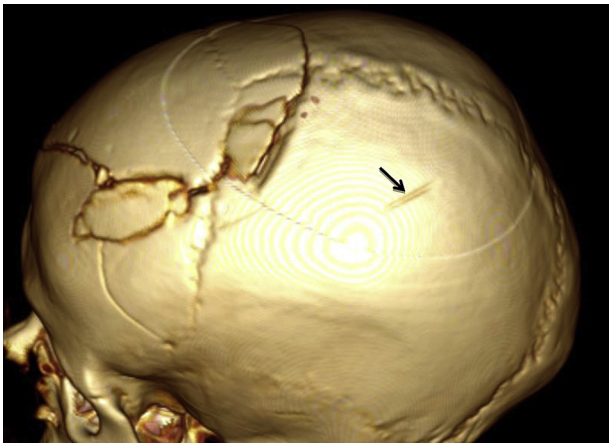

Fig. 6. 3D CT reconstruction of left side and top of skull vault. Note two clear chop fracture sites with lifted external components and separate short linear bone groove on the left side of the vault (arrowed).

3. Discussion

The reliable interpretation of injury requires a careful consideration of all the available physical and medical evidence, set in the context of the case. This can be particularly difficult in serious life threatening cases, where the emergency treatment of the injuries is the immediate priority. It is usually only after the patient's condition stabilises, that the focus shifts to gathering of evidence to support the investigation into the circumstances in which the trauma was sustained. By this stage, injuries may have been significantly modified by the treatment instigated and by healing changes within the wounds. The forensic expert tasked with assessing such a case, needs to ensure they have access to all the relevant material including the full clinical record, photographs and any radiological imaging. Given the now widespread use of CT in emergency clinical practice, this data should also be put to optimal use. Whilst in some instances (such as a closed head injury

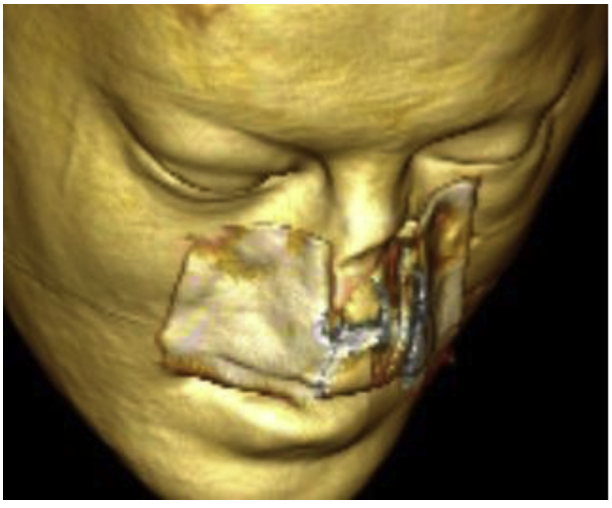

Fig. 7. 3D CT reconstruction. Note incised injury across the bridge of the nose beneath a medical dressing in place at the time of the emergency CT scan.

following a fall), review of the existing two dimensional (2D) CT images with a radiology colleague may suffice in identifying key features such as the distribution of brain contusions, the extent of intracranial bleeding and any linear fracturing, in other instances further work on the data, beyond that necessary for clinical management, might be warranted. The forensic application of 3D CT reconstruction is becoming increasingly recognised and is particularly valuable in survivors of life threatening injury, where this may provide evidence not otherwise available, since no post mortem investigation will take place.

In the presented case, the 3D CT bone reconstruction elegantly displayed characteristic chop fracture damage to bone[12,13] typical of axe or hatchet trauma, which was positioned beneath the sutured scalp and facial tissues. This supports the approaches taken by Grassberger et al.[9] and Wosniak et al.[10] who recently demonstrated the use of these techniques in defining the skull fracture pattern associated with blows from a hammer and a poker handle, respectively. The sensitivity of the technique, which is dependent on the resolution of the original scanning data, is highlighted by identification of the fine surface bone grooving in the presented case and suggests that focal surface weapon skull vault damage (including for example from knife tip impact) should be identifiable by this method. The application of 3D CT reconstruction over a series of such cases will be necessary for proper evaluation of the technique. It was recognised that the court might be reluctant to allow expert opinion to be expressed in this serious criminal case, based on interpretation of 'virtual' imaging. The court was therefore invited to visit the department to see how the 3D CT imaging was performed and then interpreted, but this didn't prove to be necessary. The acceptance by the judge (and ultimately the jury) of the conclusions drawn from the 3D CT reconstruction in this case, supports the approach which was taken. The joint assessment of the reconstructed images by an experienced forensic pathologist, practiced in the examination and assessment of weapon marks and fracture patterns on the skull vault surface at autopsy, with experienced radiologists using 3D CT imaging in routine clinical practice, proved to be effective in reaching a balanced and defensible opinion, which was subsequently presented in court as part of the overall medical evidence by the instructed forensic pathologist. This is an approach that has been advocated by others.[9–11]

4. Conclusions

Our experience supports the conclusions reached by Grassberger et al.[9] and we recommend that consideration be given to the review of 3D reconstructed pre-treatment CT images, in cases of major head and face trauma caused during alleged assaults, particularly where a sharp penetrating weapon is believed to have been involved. This applies whether the victim survives or subsequently dies and becomes the subject of an invasive post mortem examination. We expect that in some instances, previously unattainable evidence central to injury interpretation, may be made available to the medico-legal investigation. The resultant images can also be used to demonstrate the injuries at court, in a practical and sanitised way. The further exploration of the use of 3D CT reconstruction to support injury interpretation in forensic medicine and pathology is to be strongly encouraged.

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Conflict of interest
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